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The pipeline problem in review

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THE PIPELINE PROBLEM IN REVIEW

by

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INTRODUCTION

We are in the midst of a search for better ways of "technology assessment"[1] in which the objective is to define and evaluate the interactions between new technological developments and society and the environment. A current Canadian example of technology assessment is the pipeline-related social science and natural science studies that have been conducted in the Mackenzie Valley and northern Yukon from 1971 to the present. It was logical, then, that the organizers of this symposium on energy resources should select the "pipeline problem" as one element of a session on environmental considerations. Proposals to construct one or more pipelines from the north bring into focus several subjects that are not so much "pipeline problems" as they are problems of defining scientific work objectives that will be of use to those who must decide whether these proposals for technological developments are acceptable. This paper will not discuss specific "problems" that a northern pipeline might pose for the environment because that vast subject is dealt with in various reports by proponents of the project[2], by Government[3] and by third-party review groups[4]. Instead, current pipeline-related studies will be used as a source of examples to analyse the strengths and limitations of the development-related approach to scientific field studies. These examples could just as well have been drawn from other likely technological developments such as strip-mining or reservoir creation.

Most of the northern pipeline studies of the past three years have been sponsored either by prospective applicants for construction of a gas or oil pipeline or by the Government of Canada. In industry's case, the broad purposes of the environmental studies were: to determine what environmental losses or benefits would result from the proposed project and what threats to engineering facilities were posed by the natural environment; to apply environmental data to the development of better project routing and project design, and; to meet guidelines laid down by Government on a number of ecological concerns. In the case of Government, the broad purpose of the studies that were accelerated in 1971 was to ensure that Government was in possession of adequate information on the northern environment to be able to assess applications for a gas or oil pipeline in the Mackenzie Valley and northern Yukon and to reach decisions that would balance possible interference with the environment against possible economic and social benefits.

These broad objectives on the part of both industry and government resulted in a series of pipeline-related environmental studies that, without question, have exceeded in magnitude any previous project-related field studies in advance of an application for approval. Although the results of these studies are just now becoming available in published form, reaction to this unprecedented marriage of industrial engineering and environmental sciences has ranged from hints that it is nothing more than a liaison of convenience to suggestions that the problems are all solved because of these advance studies or because "good engineering and environmental protection are synonymous"[5]. As usual, a position somewhere in the middle is probably a more accurate assessment.

Because the northern pipeline studies are an example of the kind of environmental field research that industry and governments most readily support financially today, it is the purpose of this paper to briefly examine this development-related approach to environmental research in terms of its advantages, its limitations, and its ability to produce results that are scientifically sound, legally defensible and sociologically important. The theme of this paper is that this project-related approach is a very practical way for decision-makers to obtain technical data and opinions of scientists on the expected *primary* influences of a proposed project but that it only partially meets the expectations that today's public has for the prediction of *secondary* or *tertiary* environmental side-effects. Emphasis is given to the distinction between *prediction* (measurement and interpretation *before* the project) and *assessment* (measurement and interpretation *after* the project) of environmental influences resulting from large industrial projects. Because our predictive abilities are so dependent upon actual assessments of case histories, the main recommendation of this paper is that any large public works or industrial project should have, as an integral part, the establishment of ecological reserves to serve as experimental control areas for the actual assessment of the project's side-effects.

ADVANTAGES OF THE PROJECT-RELATED APPROACH TO ENVIRONMENTAL STUDIES

Large projects such as proposed northern pipelines present two distinctly different questions as far as application of ecological criteria is concerned. First is the broad question of whether, on environmental grounds, the project should proceed; second, if the project does proceed, are questions of how ecological information can be applied to avoid problem areas during construction, how to design a project that will lessen environmental side-effects, how to ensure the safety of man-made structures, and how to stipulate protective measures for the long-term management of renewable resources. For either the primary "Go or no go" question or the secondary "How to do it better" questions, it is evident that a project-related orientation for environmental field studies is a very practical way to obtain technical data and opinions pertinent to the proposed project.

While the long-term mapping and data-collection programs of Government agencies routinely assemble background information useful in assessment of project proposals, the temporary placement of these field programs into a project-related framework has the advantage of helping to set priorities where there are choices of geographic area to be covered by the sampling or mapping program. On a more local scale, it is also true that a project-related program will allow a particular sampling point - let us say a gauging station on a tributary of the Mackenzie River - to be located in such a way that it gives information for geographic areas of concern to the proposed project, for example a specific river crossing, but also provides data needed for the agency's own long-term program. If sampling stations from a wide variety of disciplines or agencies are located according to the agency's own criteria, and outside of the guidelines of a proposed project that may have data needs for very specific points on the map, then there is less chance that the selected sampling sites will be located to provide information both for the long-term network needs and for the specific proposed project. In some cases, however, physical or biological criteria determine where sampling points must be located regardless of the location suggested by the proposed project.

Another important advantage of the development-related approach to research funding is that it provides an alternative to the traditional approach of obtaining fairly general knowledge. For projects such as a northern pipeline you do need specific information based upon local investigation and, in fact, one of the problems in delineating the distribution of ground-ice is that it is often difficult or very expensive to get specific enough in a sampling program because alternations from a frozen to an unfrozen state or from high ice-content soil to low ice-content soil may occur at intervals of a few feet.

No matter how comprehensive the available ecological information, it is of little practical use if it is not incorporated into design criteria, construction plans and operational procedures of the proposed project. The chances for engineering and environmental planning to go hand in hand are increased if the environmental investigations are organized and planned around a specific proposed project. The chance of blending engineering and ecological technology will normally be greater for the proponent of a project than it is for the regulator of a project because, in the early phases at least, the proponent will possess the most detailed information on engineering features.

LIMITATIONS OF THE PROJECT-RELATED APPROACH TO ENVIRONMENTAL STUDIES

Scientists repeatedly stress that until the long-term variations of ecosystem functions are known, we can only guess about the environmental influences of large projects. After several years of study related to proposed northern pipelines, the Environment Protection Board reminds us that direct or primary effects on an environmental system can often be predicted but secondary and tertiary effects are obscure, often subtle, and for the most part, impossible to predict. Yet, these effects are as important as are the more visible effects[6].

It would have been appropriate to insert an example from the northern pipeline studies to indicate what scientists mean when they refer to secondary or tertiary effects, but there are no documented examples yet because a gas or oil pipeline does not now exist in the Mackenzie Valley and northern Yukon. To give a real-life example one must turn to some other industrial event for which such effects have been observed. While this paper was being prepared, the national TV news gave an example of what we are talking about here. The first news item was an analysis of the high price of beef in North America, with the observation that the August price of Canadian beef was tied to supplies being released to market in the United States and that its price there was influenced by the willingness of Japanese consumers to pay up to $14 per pound for beef. The second news item showed the normal Japanese protein source - fish - being mixed with cement for sidewalks because the mercury content of the fish made them unfit for human consumption. In this sequence of events environmental contamination by Japanese industries led to trouble at the fish market[7] which, in turn, influenced the price that we paid for beef this summer and autumn. This is an example of a tertiary or higher order side-effect of Japanese industry upon environment and society and there are two lessons in it. First, the complexity of this example indicates that even if we assemble our research efforts around a project-related approach there are serious limitations to our predictive capabilities for such subtle effects because someone writing an environmental impact prediction for Japanese industries that discharge mercury would surely not have included comments on the price of North American beef. Second, although newspapers like to carry articles on "Our costly cleanup"[8] the cost of not cleaning up is rarely documented, yet the Japanese case of mercury contamination, by eliminating a vital source of protein from the marketplace, is costing many people something every week.

Those who must make decisions on the environmental acceptability of proposals such as northern pipelines want to know which of the predicted primary effects are most significant in terms of duration and magnitude and which are most likely to be reversible through remedial measures. These kinds of information are obtainable only from actual assessment of existing similar projects or from simulation experiments and this poses very demanding requirements both for timing and duration of project-related studies. The time-scale problem in ecological studies is well publicized by the pleas of ecologists for more time to carry out necessary data collection. Surprisingly, we often overlook the fact that the time required to explore and prove up a major oil and gas field in the north is probably not very different from the time required to obtain environmental data on the behavior of rivers and ice, population changes of wildlife species, responses to surface disturbance, or recovery rates of various ecosystems; in both cases a decade seems to be a reasonable minimum time requirement. In the example of northern oil and gas development, environmental onsiderations have entered the picture in an important way only as we approach the time of commitment for transportation of the resource. The weakness of placing a considerable environmental research effort on only the later phases of a proposed development needs no elaboration. Research planning organizations and conferences such as this one should devote considerable effort to initiation of environmental data collection in geographic areas that will be

the focus of the phases of energy development that are expected to be dominant 10 and 20 years from now. This would mean, of course, that fewer dollars and scientists would be available for assignment to the shorter-term project-related problems that are upon us now.

Other limitations to the project-related approach centre around features of the environment itself. It has been argued that it is the *functions* of ecosystems that determine the value of the natural environment[9]; these functions included concepts such as 'resiliency', 'stability', 'edge effects', 'transfer mechanisms' and 'sinks'. Research into freshwater ecosystems under the International Biological Program has demonstrated that to describe the stabilizing functions of an ecological system there is no substitute for experimentation under known or controlled stresses[9]. This kind of experimentation simply cannot be undertaken in project-related studies that, of necessity, are normally limited to three or less years in duration. Such experiments can be *initiated* during project-related field studies but the secondary and tertiary effects can be predicted only from a knowledge of the actual functional processes. This point is made here not to repeat the well-known generalization that everything is inter-related in ecosystems; the point rather is to indicate that we have not yet reached the point of sophistication in our ecological studies to allow someone to say to a developer "You cannot do that" because of some chain of events that will make his proposed action detrimental to something that is some distance removed in functional terms. It is here that a scientist must be on very sure ground if he is to present a scientifically sound and legally defensible argument. This level of sophistication will not be obtained from project-related studies alone; it requires as well the experimentation that is possible only in research institutions that have a long-term mandate for research into basic mechanisms of ecosystem functions.

A diversion is in order at this point to give examples of practical application of two functional features of ecosystems. In simplified ecological terms, a 'sink' may be viewed as a place of accumulation of materials that are normally cycling through ecosystems - phosphorus in lakes is a well-publicized example. A recent U.S. court case that dealt with a stream channelization project in North Carolina[10] resulted in a decision that the environmental impact statement failed to consider the *cumulative* impact of such relatively small undertakings on the regional environment. This is an example of an argument that could not be scientifically advanced without some knowledge of 'sinks' in the ecological sense of the word. As a second example, 'edge effects' could be important if one has to decide whether a particular area is better to preserve or better to be disturbed by some proposed development. One would be required, presumably, to place some "value" upon the area proposed for non-development. The normal tendency would be to estimate value on the basis of size with the assumption that a large ecosystem would have a greater value than a small ecosystem. But this relationship is not necessarily true because external relations are functions of the *edge* of a system rather than the total volume or total area[9]. These examples are important because such concepts find application in the post-1970 style of Federal environmental legislation that has been developing in Canada, with emphasis on the regulatory approach. This approach puts the primary responsibility upon the Government to inform

itself on a broad range of technical subjects, to prescribe tolerable limits for various things discharged to the environment and to carry out surveillance to ensure that standards and objectives are met[11]. Clearly, while project-related studies such as the northern pipeline investigations can assist regulatory authorities in their statutory responsibilities, the long-term execution of these responsibilities depends upon environmental studies and monitoring that extends beyond the normal life span of project-related field work.

The project-related approach to environmental studies has, by definition, the effect of focussing the researchers attention upon events that may occur if the project should proceed. For example, the northern pipeline studies quite logically generated several projects to test the effects of oil upon northern land or freshwater ecosystems. By focussing on potential oil spills as an object of study, research fell into the category that Hare has identified as "short-term corrections of technological errors"[12]. This is a natural tendency in project-related work, with the result that somebody else has to worry about the other approach to environmental studies that deals with long-term design and management of the environment. Staying with the oil-spill example, the latter approach would analyse the causes of pipeline rupture, would note that by some sets of statistics about 40% of liquid pipeline ruptures are attributed to external corrosion[13], and would then design research to test hypotheses that external corrosion of pipelines is influenced by bedrock or soil chemistry, by groundwater chemistry, by soil microbiology, or perhaps by soil microclimate. Then, if relationships were established between regional variations in incidence of pipeline rupture and variations in some proven causative factor, it might be possible to specify certain landscapes that should be either avoided by pipelines or that would require extra corrosion-resistant treatments of buried pipe. Clearly, this latter experimental approach does not fit with the terms of reference for project-related studies that are carried out in advance of an application, yet this approach is an important element of long-term environmental management.

Similar to this oil-spill example are project-related studies on water resources. Such studies must of necessity focus on objectives of immediate interest to those who must assess an application for the proposed project[3] but they tell us little about long-term management questions such as 'Which bodies of water could be zoned for which uses?' 'Can small, landlocked, pothole lakes be used to receive wastes?' 'Are there small lakes that are virtually "dead" in a biological sense which could be intensively used for waste disposal and then filled?' or 'What precautions are needed for areas of predictably high use such as the alluvium in terraces along perennial rivers in the north where the best probable supplies of year-round good quality groundwater are expected to occur?'[14].

Finally, a practical limitation to the effectiveness of project-related studies is their dependence upon background knowledge gained by many years of basic study by universities and Government research establishments. Because the drawing of research scientists into project-related studies is a recent phenomenon, one can assume that in the past a larger portion of this manpower resource was devoted to general

advancement of our knowledge about the natural environment. If there is a trend for an increasing proportion of research and survey expertise to be allocated to projects related to development proposals - and there is no evidence presented here that there is such a trend - then in the long-run the consultants and the applied ecologists who devote themselves to the project-related studies will find their traditional sources of basic data, the long-lived research institutes, progressively less helpful. Maintenance of a balance between long-term academic investigations and application of that knowledge to specific projects seems essential.

OUTPUT FROM THE PROJECT-RELATED APPROACH TO ENVIRONMENTAL STUDIES

From the relative lengths of the two preceding sections in this paper, the reader might conclude that the limitations exceed the advantages for project-related environmental studies. That is not necessarily the case, and the main point to be observed is that there are certain things that such studies can do well and other things that, from a scientific point of view, are better left to other avenues of investigation.

If we recall the earlier summary of the original broad objectives of the pipeline-related advance studies, both for industry and for Government, the organization of various study groups around the proposal for a specific large project seems to be the most efficient and practical way of satisfying those objectives. This approach is well suited for rapid assembly of technical data and opinions on the predicted *primary* environmental influences of the proposed project.

However, the public expectation for prediction of influences of large projects includes *secondary* and *tertiary* effects. For reasons outlined in the preceding section, organization of research and surveys around specific development proposals tends to focus attention on questions directly related to the acceptability of the project and away from research objectives related to longer-term environmental management. This means that for those who must decide whether or not a large proposed project is to proceed, the best source of applicable information is from the project-related studies done in advance of application; for those who must try to predict secondary effects or who must direct their attention to broader aspects of environmental management there are other *assessment* techniques that are better than the *predictive* techniques that now dominate project-related environmental studies. One possible avenue to encourage such assessments is recommended in the closing section of this report.

One is led to stress the distinction between the predictive approach based on measurements and interpretation in advance of project start-up and the assessment approach in which actual effects are measured and interpreted. In the long run, the latter approach is the more important one because the documentation of case histories not only gives results that are scientifically sound but it also improves our prediction capabilities for future large-scale industrial projects. In general, environmental studies will also become more important sociologically if they can reach a level of sophistication that includes secondary or higher-order effects that

are based on actual measurements of case histories. One possible approach to this goal is outlined next.

ECOLOGICAL RESERVES AS EXPERIMENTAL CONTROLS FOR LARGE PROJECTS

The theoretical basis for concern about development-related environmental changes is that such changes may be of such magnitude or speed to exceed the adaptive capabilities of populations in ecosystems that are the product of several thousands of years of natural selection. The history of ecological studies in North America is that such man-made changes are frequently not observed until it is too late to do much about it. For this reason, one of the most critical needs of environmental management is an ability to *predict* the influences of human activities[15].

As public pressures have forced ecologists to make their science an applied one, there has come an uncomfortable realization of how poorly we understand the functioning of undisturbed ecosystems and, because ecologists have traditionally favored undisturbed areas for study, it goes without saying that we understand even less about functions in disturbed ecosystems. It is this intensified realization of the absolute need for environmental yardsticks, against which conditions on disturbed areas can be assessed, that has led professional ecologists to be strong advocates for preservation of ecological reserves that will serve as the yardsticks of the future. Unfortunately, this need for ecological reserves is not widely appreciated because advocacy for such reserves is usually indiscriminately grouped with demands for wilderness preservation, parks development, or moratoria on development. Under specific circumstances, the latter demands upon land or upon land-use policies can be important in their own right; wilderness, parks or areas declared for a moratorium on development all possess the feature of being more or less incompatible with large resource development projects. In contrast, ecological reserves may require only a central core - the long-term experimental *control* area - that needs to be out-of-bounds for land-use practices that would disturb the surface. The rest of the reserve could be used to measure the actual effects of local environmental alterations from power plants, highways, pipelines, or other rights-of-way. This concept of setting aside areas in which actual environmental impact will be assessed during the life of a project, instead of just trying to *predict* environmental influences in advance of the project, leads to the suggestion that there be a requirement for the establishment of ecological reserves as an integral part of any large public works or industrial project[15]. The idea is that these reserves would be specifically set aside as experimental controls for the project, and the costs of monitoring should be considered as a project expense. In the long run, our ability to predict environmental influences of major new projects, such as northern pipelines, would be improved if there was deliberate establishment of such areas on which true environmental impact assessments were carried out over a number of years. Historically, the ecological literature suggests another reason why the application of ecological principles to land-use practices could advance if this suggestion were put into practice. For example, Peterken's analysis of 141 published ecological works[16] shows that only a small portion of ecological research projects include research in which the experimenter deliberately modifies

the ecosystem to observe the consequences. Notable exceptions are the oil-spill studies on land at Norman Wells, in a stream of the northern Yukon and in a lake of the Mackenzie Delta as part of the Environmental-Social Program of the Government of Canada[3], and the Devon Island Project of the International Biological Program which included manipulative studies on removal of surface vegetation, driving tracked vehicles over vegetation, and fuel spills on vegetation[17].

We do not yet have a North American text on the ecology of disturbance and natural recovery in natural communities, but there is good reason to expect that manipulative ecological research will become more common because restorative ecology will be an increasingly important objective as more major developments are laid upon the land. Ecological reserves that would be tied to major development projects have an important role here because disturbances created by the project in or adjacent to the reserve could reduce the need for deliberate experimental disturbance. A practical way of building this suggested approach into an ecological reserves system is to recognize, as Britain does, that there may be a number of different classes of ecological reserve. For example, although Britain does have certain reserves that are examples of relatively undisturbed habitats and are set aside solely to preserve the fauna and flora, there are others that are thought of and managed primarily as public open spaces but are also important refuges for fauna and flora that survive there despite the disturbance[18]. Ecotypes that have evolved on disturbed lands possess high tolerances to conditions on these particular sites and in the case of some grasses this adaptation to a particular habitat may occur in as little as 50 years[19]. In Britain, this ecological principle is applied to the point that ecotype selection and seed production *directly on the site to be reclaimed* is considered to be as important as surface treatments. Thus, in a world of increasing disturbance to the land surface, ecotypes adapted to disturbances may themselves take on added value as important gene pools of the future. The establishment of ecological reserves for long-term study and preservation of these gene pools, for actual assessment of responses to disturbance, and for documentation of recovery rates, is strongly recommended as a step to improve our abilities to predict environmental side-effects of large industrial projects.

Finally, how can the problems of extrapolating research results from one study area to another or extrapolating a project's documented side-effects to another proposed project be assisted by a system of ecological reserves? This is an especially important question in the north which gives the impression of great similarity over a broad geographic area with the result that arctic or subarctic resource developers may possess an unjustified sense of security in broad geographic extrapolation of test results. Biologists know that assemblages of species depend very much upon local variations in landform, microclimate, distribution of near-surface groundwater, history of lightning fires, other disturbances, and availability of colonizing populations. It is these local variations that give a complex mosaic pattern to what is otherwise a broad bioclimatic zone. It is also these local variations that make isolines on a map and regional averages (such as average peat thickness or average depth of active layer) quite meaningless. The authors and users of environmental impact assessments will

come to appreciate the full significance of these local variations if there is a widespread and continuous documentation of the side-effects of various projects where they traverse experimental zones within geographically dispersed ecological reserves. If the network of ecological reserves follows the International Biological Program guidelines for regional representation of major ecosystems, the documentation of specific disturbances in a series of reserves spread over a broad geographic range will tell us much more than we now know about the limits of extrapolation of development-environment interactions.

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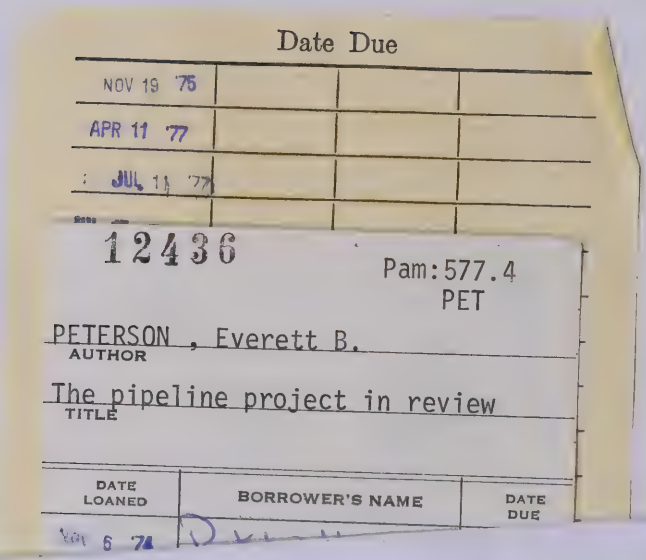

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